Eco. Env. & Cons. 30 (2) : 2024; pp. (944-952)
Copyright@ EM International
ISSN 0971–765X

DOI No.: http://doi.org/10.53550/EEC.2024.v30i02.087

Emerging Perspectives on Plant-Based L-Dopa Sources for the Treatment of Parkinson's disease

Sagar Shinde*, Athoiba Singh[1], Shekhar Shinde[2] and Jagtap Suresh[3]

[1]Department of Plant Biotechnology, Rajiv Gandhi Institute of IT and Biotechnology Bharati Vidyapeeth (Deemed to be) University, Dhankawadi, Pune 411 043, M.S., India
[2]Department of Mechanical Engineering, Bharti Vidyapeeth (Deemed to be) University, College of Engineering, Pune 411 043, M.S., India
[3]Bharati Vidyapeeth (Deemed to be University), Interactive Research School for Health Affairs (IRSHA), Pune Satara Road, Pune 411 043, India

(Received 12 February, 2024; Accepted 7 April, 2024)

ABSTRACT

L-DOPA (L-3, 4-dihydroxyphenylalanine) is a crucial pharmacological agent in the treatment of Parkinson's disease (PD). As a precursor to dopamine, its administration serves to address the dopamine deficiency. Dopamine is a neurotransmitter and plays a prominent role for motor control and coordination is severely depleted in PD patients, leading to debilitating motor symptoms. L-DOPA crosses the blood-brain barrier, where it is converted into dopamine, While L-DOPA remains the gold standard for PD management, and this review will focus on plant-based L- DOPA sources as an alternative to synthetic L-DOPA in treatment of Parkinson's disease. While synthetic L-DOPA which can be associated with various side effects. Plant-based L-DOPA, derived from natural sources such as Mucuna pruriens, *Vicia faba* and along with other plants offer a promising alternative for the management of Parkinson's disease. Different studies have demonstrated the effectiveness of *Mucuna pruriens* and other L-DOPA containing plants to alleviating motor symptoms in Parkinson's. Furthermore, the use of natural plant-based L-DOPA may offer advantages in terms of reduced cost and increased availability, particularly in regions where conventional pharmaceutical L-DOPA preparations may be less accessible collectively, the evidence to date suggests a promising future for plant-based L- DOPA sources in the management of Parkinson disease. However, additional research is required to address issues such as the optimal quality and duration of intake as well as potential mechanisms. Studies in the above areas will help formulate optimum dosage. Overall, plant-based L-DOPA holds promise as a complementary approach to conventional therapy, offering potential benefits for those living with Parkinson's disease.

Key words: *Parkinson's disease, L-DOPA, Mucuna pruriens, Neurological disorder*

Introduction

Parkinson's disease overview

Parkinson's disease (PD) is a chronic and progressive neurological disorder that was initially characterized and documented by James Parkinson. It has since emerged as the second most prevalent

Abbreviations
PD: Parkinson's disease
L-DOPA: L-3,4-dihydroxyphenylalanine

neurodegenerative condition on a global scale. As the disease advances, many patients grapple with motor complications, notably dyskinesia, which can significantly amplify both the financial and psychological toll of the illness (DeMaagd *et al.*, 2015). This burden is not limited solely to the affected individuals and their families; it extends to society. In recent years, PD has exhibited remarkable growth in its prevalence, making it one of the most rapidly proliferating neurological disorders worldwide. Consequently, the corresponding global burden of PD has more than doubled within a single generation. This escalating burden underscores the pressing need for scientific research, enhanced medical interventions, and increased societal awareness to effectively address the multifaceted challenges posed by Parkinson's disease (Zheng, *et al*., 2023; Vilairat, *et al*., 2023).

Pathophysiology

In PD, the dopamine deficiency leads to an overactive indirect pathway and an underactive direct pathway, resulting in motor symptoms such as bradykinesia, rigidity, resting tremors, and postural instability. Furthermore, beyond the motor domain, PD's pathophysiology extends to various non-motor symptoms, including mood disturbances, cognitive impairment, and autonomic dysfunction, indicating its multifaceted impact on the brain. While the exact cause of dopaminergic neuron degeneration remains elusive, emerging research points to a combination of genetic, environmental, and oxidative stress factors contributing to the disease's progression. Understanding the intricacies of PD's pathophysiology is essential for the development of targeted halting its debilitating effects. Dopamine is a neurotransmitter, normally facilitates the modulation of motor functions by balancing the direct and indirect pathways in the basal ganglia (Sushama *et al*., 2013; Dorsey *et al*., 2018).

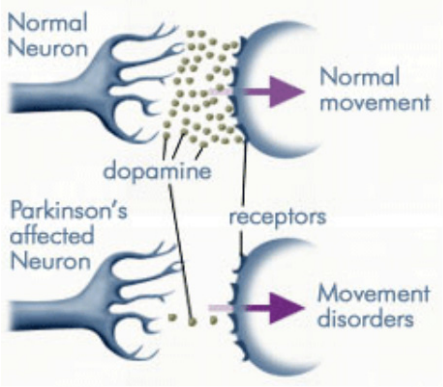

Fig. 1. Pathophysiology of Parkinson's disease (Dopamine levels in a normal and Parkinson's affected neuron)

Factor Involving In Parkinson's Disease

Parkinson's disease is a complex neurodegenerative disorder with both genetic and environmental factors contributing to its development (Dorszewska *et al*., 2021; Inamdar, *et al*., 2013).

L-DOPA AND PARKINSON DISEASE

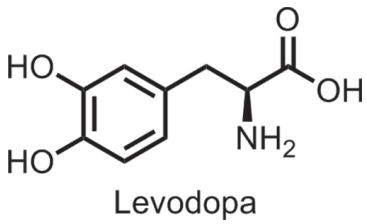

Fig. 3. Structure of Levodopa

Top of Form

L-DOPA which is the naturally occurring form of the amino acid 3,4-dihydroxyphenylalanine, was

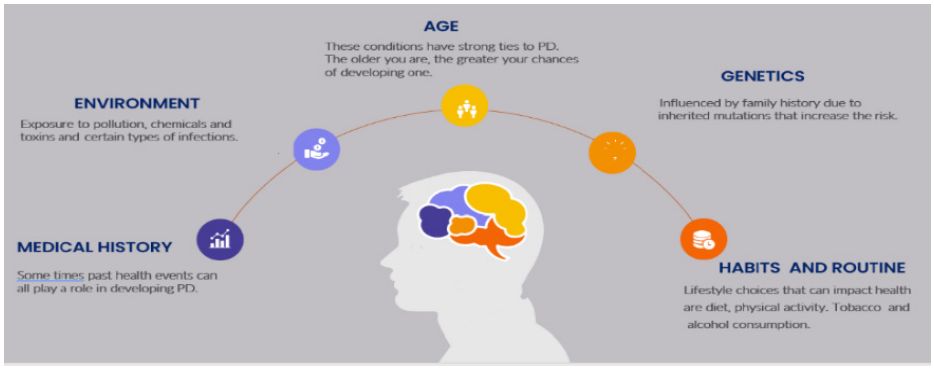

Fig. 2. Factor involving in Parkinson's disease

initially extracted and identified from leguminous plants in the year 1913 (seedlings of *Vicia faba*) by Marcus Guggenheim (Mali, *et al.,* 2023; Hornykiewicz, 2002). The most efficacious therapeutic intervention for Parkinson's disease (PD) involves the administration of L-DOPA, serves as a critical precursor to dopamine, the neurotransmitter whose deficiency characterizes PD pathology. This treatment approach, whether employed independently or in combination with an aromatic amino acid decarboxylase inhibitor such as carbidopa or benserazide, has proven to be the foremost pharmaceutical strategy for managing PD symptoms (Brauer *et al*., 2020; Murthy *et al*., 2015). This is primarily due to the inherent incapacity of dopamine to traverse the blood-brain barrier, as reported by Kofman in 1971. The global L-DOPA market exhibits a remarkable annual production volume of approximately 250 metric tons, with an associated economic value exceeding $101 billion per year. This underscores the substantial demand and reliance on L-DOPA as a pivotal therapeutic agent in the realm of PD treatment. Levodopa is on the WHO Model Lists of Essential Medicines (Bloem *et al.,* 2021; Murthy *et al*., 2015).

Present Status of Availability of Levodopa in Low-income Country

In rural Sub-Saharan Africa, only 15% of Parkinson's disease (PD) patients receive levodopa treatment due to its limited availability in pharmacies, high costs, and lack of generic options. Ghana does not include levodopa in its Essential Medicines List, causing difficulties in accessing it in government pharmacies (Ramya *et al.,* 2007; Inamdar *et al*., 2013). While Kenya includes levodopa + carbidopa, there are no registered brands. Levodopa availability is inconsistent in the Western Pacific region, particularly in low-income countries like Cambodia and Laos. Levodopa is unaffordable in many low-income countries, with the cost of 100 branded tablets in Kenya being $48. This is unsustainable for most of the population in Sub-Saharan Africa, where over half the people live on less than $2 per day (Mali *et al*., 2023). Affordability challenges are also observed in Nigeria and Ghana. In India and China, the economic burden of PD is reported. Availability and affordability studies in countries beyond Sub-Saharan Africa are limited, but it's essential to address these issues, as untreated PD can lead to severe suffering, rapid deterioration, and early mortality

L-DOPA TIMELINE

Year	Achievement	References
1911	Synthesized as D,L dopa racemate in the laboratory	(Hornykiewicz *et al*., 2002)
1913	levodopa isolated from Vicia faba(fava bean) seedlings	(Vilairat *et al*., 2023)
1916-1939	Levodopa's effects on blood sugar, arterial blood pressure, and its role in skin melanin were studied in rabbits.	(Dorsey *et al*., 2018)
1938	L-Dopa decarboxylase enzyme identified	(Vilairat *et al*., 2023)
1940	Found in adrenals and brains	(Dorsey *et al*., 2018)
1941-42	Decarboxylated to DA in animal and human body	(Hornykiewicz *et al*., 2002)
1941-45	Vasoactive in normal and hypertensive animals and humans	(Hornykiewicz *et al*., 2002)
1950-1960	Catecholamine depletion reversal was explored alongside describing striatal dopamine deficiency in Parkinson's patients.	(Dorsey *et al*., 2018), (Vilairat *et al*., 2023)
1961	First reported trial of intravenous in PD	(Dorsey *et al*., 2018), (Vilairat *et al*., 2023)
1967	Benserazide enhances levodopa activity, demonstrating efficacy in oral administration for parkinsonism.	(Dorsey *et al*., 2018), (Vilairat *et al*., 2023)
1969	First double-blind,placebo-controlled study showing efficacy of levodopa but with development of choreiform movements	(Vilairat *et al*., 2023)
1969	Combined levodopa decarboxylase inhibitor RO4-4602 (benserazide) proves more effective than levodopa alone	(Vilairat *et al*., 2023)
1973	Sustained release formulations L-Dopa	27
1974	Clinical use of carbiodopa-levodopa reported	(Vilairat et al., 2023)
1975	Continuous levodopa administration tried for preventing complications (Hornykiewicz *et al.,* 2002)	(Vilairat et al., 2023)
1975	Levodopa -benserazide (Madopar) commercialized	(Dorsey *et al*., 2018), (Vilairat *et al*., 2023)

1975	Carbidopa- levodopa (Sinemet) commercialized	(Vilairat *et al*., 2023)
1982	Dopamine agoinst adjunct with L-dopa for better results	(Dorsey *et al*., 2018)
1989	Sustained-release carbidopa- (Sinmet CR) reduces off time and improves clinical disablity better than standard carbidopa-levodopa (Sinemet), but effect are variable	(Vilairat *et al*., 2023)
1989	Two COMT inhibitors found to be orally active	(Vilairat *et al*., 2023)
1990	On and off fluctuations with continuous L-Dopa administation	(Dorsey *et al*., 2018)
1991	Sustained-release carbidopa levodopa infusion	(Vilairat *et al*., 2023)
1993	First clinical trial of enteral carbidopa-levodopa infusion	(Dorsey *et al*., 2018), (Vilairat *et al*., 2023)
1994	L-Dopa potency rises in combination with COMT inhibitors	(Dorsey *et al*., 2018)
1997	Controlles release combinations proved to be more effective	(Dorsey et al., 2018)
1998	First COMT inhibitor became commercially available (talcapone: Tasmar)	(Vilairat *et al*., 2023)
2003	Combination carbidopa-levodopa -entacapone tablets (Stalevo) become commercially available	(Vilairat *et al*., 2023)

(Bapat *et al*., 2019; Crapnell *et al*., 2023).

Plant Based L-dopa

Natural sources of L-DOPA, such as legumes and seeds, can offer potential advantages in Parkinson's disease treatment. They are rich in nutrients, provide sustained release, contribute to dietary variety, and may contain other compounds that could have synergistic effects or complementary benefits **(**Jagtap *et al*., 2010; Abbott *et al*., 2010). The scientific journey of plant-based L-DOPA began in 1913 when the pioneering scientist *Marcus* Guggenheim achieved the historic milestone of isolating L-DOPA from the seedlings of Vicia faba, thus marking a significant breakthrough in the understanding of this compound's presence in nature (Yang *et al*., 2001). Various plant species have been scientifically documented as containing L-DOPA, affirming its presence and distribution across a diverse range of botanical specimens. Furthermore, it is worth noting that the Genus Mucuna has consistently demonstrated the highest recorded levels of L-DOPA content among all documented botanical sources, aside from those previously mentioned (Raina *et al*., 2011).

Genus Mucuna

Genus Mucuna, belonging to the family Fabaceae, represents a taxonomically diverse and pharmacologically significant group of leguminous plants. This genus comprises approximately 150 species found worldwide distributed primarily in tropical and subtropical regions across the globe (Ingle *et al*., 2003). The hallmark characteristic of Genus Mucuna is its production of L-Dihydroxyphenylalanine (L-DOPA), a pivotal precursor in the biosynthesis of neurotransmitters like dopamine. *Mucuna* species are renowned for their rich L-DOPA content, with some varieties containing exceptionally high concentrations of this bioactive compound. This chemical richness has garnered substantial attention in both traditional and modern medicine, as L-DOPA plays a central role in the treatment of Parkinson's disease (14). Table 1 has shown list of reported Mucuna spices having significant amount of L-DOPA content. Apart from these species *Mucuna pruriens* is predominantly cultivated in indigenous tropical regions such as Africa, India, and the West Indies. M. pruriens is globally recognized for its remarkable pharmacological potential against a various disease majorly often accompanied by minimal or negligible adverse effects. The seeds of *Mucuna pruriens* are notably abundant in L-DOPA, alongside a range of secondary metabolites of alkaloids, trypsin, histidine, glutathione, and a diverse array of amino acids. The methanolic extract of *Mucuna* seeds has been characterized for its exceptional purity, containing a remarkable 92% concentration of L-DOPA (Min *et al*., 2015; Fothergill-Misbah *et al*., 2020).

Plant Rich in L- Dopa Other than Genus Mucuna

While the Mucuna genus is prominent for its high L-DOPA content, there are additional plants beyond this genus that also contain measurable amounts of L-DOPA. One such example is Vicia faba, *Bauhinia purpurea* Linn, *Canavalia ensiformis*, *Cassia hirsute* and much more. While the L-DOPA concentrations in these non-Mucuna plants tend to be lower in comparison, they nevertheless represent intriguing natural sources of this valuable compound **(**Crapnell *et al*., 2023; Haddad *et al*., 2017). The presence of L-

Sr.No	Plant	Plant part	L-Dopa %	References
1.	*Mucuna andreana.*	Seed (excluding seed coat)	6.3-8.9 %	(Ramya *et al*., 2007)
2.	*Mucuna aterrima.*	Seed	3.31	(Ramya *et al*., 2007)
3.	*Mucuna aterrima.*	Seed (black)	4.2	(Ramya *et al*., 2007)
4.	*Mucuna birdwoodina tutcher*	Seed	9.1	(Ramya *et al*., 2007)
5.	*Mucuna cochinchinensis.*	Seed(ash)	4.2	(Ramya *et al*., 2007)
6.	*Mucuna cochinensis*	Seed(grey)	2.05	(Ramya *et al*., 2007)
7.	*Mucuna cochinensis*	Seed	3 to 4 %	(Ramya *et al*., 2007)
8.	*Mucuna deeringiana.*	Seed	2.7-3.13	(Ramya *et al*., 2007)
9.	*Mucuna gigantean*	Seed	1.50-3.78	(Ramya *et al*., 2007)
10.	*Mucuna holtonii.*	Seed	6.13-7.5	(Ramya *et al*., 2007)
11.	*Mucuna monosperma.*	Seed	4.24-4.56	(Ramya *et al*., 2007)
12.	*Mucuna mutisiana.*	Seed	3.9-6.8	(Ramya *et al*., 2007)
13.	*Mucuna pruriens.*	Seed (excluding seed coat)	5.9-6.4	(Ramya *et al*., 2007)
14.	*Mucuna pruriens.*	Seed	1.25-9.16	(Ramya *et al*., 2007)
15.	*Mucuna pruriens.*	Seed (black.)	3.8	(Ramya *et al*., 2007)
16.	*Mucuna pruriens.*	Whole bean	4.02	(Ramya *et al*., 2007)
17.	*Mucuna pruriens.*	Endocarp	5.28	(Ramya *et al*., 2007)
18.	*Mucuna pruriens f. hirsute*	Seed	1.4-1.5	(Ramya *et al*., 2007)
19.	*Mucuna pruriens f.utilis*	Seed	1.8	(Ramya *et al*., 2007)
20.	*Mucuna pruriens var. utilis.*	White(Whole seed)	4.96	(Ramya *et al*., 2007)
21.	*Mucuna pruriens var. utilizes*	Seed (White	6.08	(Ramya *et al*., 2007)
22.	*Mucuna pruriens var. utilizes*	Seed (spotted)	3.6	(Ramya *et al*., 2007)
23.	*Mucuna pruriens var. utilizes*	Pericarp	0.16	(Ramya *et al*., 2007)
24.	*Mucuna sloanei*	Seed	3.34-9.0	(Ramya *et al*., 2007)
25.	*Mucuna sp*	Seed	1.96-4.96	(Ramya *et al*., 2007)
26.	*Mucuna urens.*	Seed	4.92-7.4	(Ramya *et al*., 2007)
27.	*Mucuna bracteata*	Seed	7.61±0.11	(Ramya *et al*., 2007)
28.	*Mucuna imbricate*	Seed	5.97 ± 0.25	(Ramya *et al*., 2007)
29.	*Mucuna pruriens var. utilis*	Seed	5 ±0.14	(Ramya *et al*., 2007)
30.	*Mucuna prurience (L.) DC.*	Seed	134.0 (mg/g)	(Jagtap *et al*., 2010)
31.	*Mucuna prurience var utilis* (wall EX. Wight) Bak.EX burck	seed	118.00 (mg/g)	(Jagtap *et al*., 2010)
32.	*Mucuna monosperma* DC. Ex Wight & Am	seed	106.0 (mg/g)	(Jagtap *et al*., 2010)
33.	*Mucuna minima* Haines	seed	084.0 (mg/g)	(Jagtap *et al*., 2010)
34.	*Mucuna championii* Benth.	seed	019.0 (mg/g)	(Jagtap *et al*., 2010)
35.	*Mucuna sempervirens* Hemsl.	seed	5.8	(Yang *et al*., 2001)
36.	*M. birdwoodiana* Tutcher	seed	5.5	(Yang *et al*., 2001)
37.	*M. macrocarpa* Wall	seed	5.9	(Yang et al., 2001)
38.	*M. interrupta* Gagnep.	seed	4.3	(Yang *et al*., 2001)
39.	*M. paohwashanica* Tang et Wang	seed	3.9	(Yang *et al*., 2001)
40.	*M. pruriens*	seed	3.62	(Raina *et al*., 2011)
41.	*M. prurita*	seed	5.36	(Raina *et al*., 2011)
42.	*M. utilis*	seed	3.31	(Raina *et al*., 2011)
43.	*M. pruriens*	seed	2.79	(Raina *et al*., 2011)
44.	*M. pruriens*	seed	2.23	(Raina *et al.,* 2011)
45.	*M. utilis*	seed	2.86	(Raina *et al.,* 2011)
46.	*M. prurita*	seed	2.82	(Raina *et al.,* 2011)
47.	*M. pruriens*	seed	2.63	(Raina *et al.,* 2011)
48.	*M. pruriens*	seed	3.45	(Raina *et al.,* 2011)
49.	*M. pruriens*	seed	3.34	(Raina *et al.,* 2011)
50.	*M. pruriens*	seed	3.27	(Raina *et al.,* 2011)
51.	*M. pruriens*	seed	2.86	(Raina *et al.,* 2011)
52.	*M. pruriens*	seed	3.13	(Raina *et al.,* 2011)

53.	*M. pruriens*	seed	4.04	(Raina *et al.,* 2011)
54.	*Mucuna andreana Micheli*	seed (excluding seed coat)	6.3-8.9	(Ingle *et al.,* 2003)
55.	*Mucuna aterrima* (Piper & Tracy) Holland	seed	3.31	(Ingle *et al.,* 2003)
56.	*Mucuna aterrima* (Piper & Tracy) Holland	seed(black)	4.2	(Ingle *et al.,* 2003)
57.	*Mucuna birdwoodina tutcher*	seed	9.1	(Ingle *et al.,* 2003)
58.	*Mucuna cochinchinensis* (Lour.) A. Chev	-	0.96	(Ingle *et al.,* 2003)
59.	*Mucuna cochinchinensis* (Lour.)A. Chev	Seed(ash)	4.2	(Ingle *et al.,* 2003)
60.	*Mucuna cochinchinensis* (Lour.) A.Chev	Seed (grey)	2.5	(Ingle *et al.,* 2003)
61.	*Mucuna cochinchinensis* (Lour.) A. Chev	seed	3 to 4	(Ingle *et al.,* 2003)
62.	*Mucuna deeringiana* (Bort.) Merr	seed	2.7-3.13	(Ingle *et al.,* 2003)
63.	*Mucuna gigantean* (Willd.) DC.	seed	1.50-3.78	(Ingle *et al.,* 2003)
64.	*Mucuna holtonii* (Kuntze) Mold.	seed	6.13-7.5	(Ingle *et al.,* 2003)
65.	*Mucuna monosperma* DC. Ex Wight	seed	4.24-4.56	(Ingle *et al.,* 2003)
66.	*Mucuna mutisiana* (Kunth) DC.	seed	3.9-6.8	(Ingle *et al.,* 2003)
67.	*Mucuna pruriens* (Linn.) DC.	Seed (excluding seed coat)	5.9-6.4	(Ingle *et al.,* 2003)
68.	*Mucuna pruriens* (Linn.) DC.	seed	1.25-9.16	(Ingle *et al.,* 2003)
69.	*Mucuna pruriens* (Linn.)DC.	Whole bean	4.02	(Ingle *et al.,* 2003)
70.	*Mucuna pruriens f. hirsuta*	seed	1.4-1.5	(Ingle *et al.,* 2003)
71.	*Mucuna pruriens f. utilis*	seed	1.8	(Ingle *et al.,* 2003)
72.	*Mucuna pruriens var.utilis* (Wall.Ex Wight)	White(Whole seed)	4.96	(Ingle *et al.,* 2003)
73.	*Mucuna pruriens var.utilis* (Wall.Ex Wight) Baker ex Burck.	seed	8.05	(Ingle et al., 2003)
74.	*Mucuna pruriens var.utilis* (Wall.Ex Wight) Baker ex Burck.	seed(white)	6.08	(Ingle *et al*., 2003)
75.	*Mucuna pruriens var.utilis* (Wall.Ex Wight) Baker ex Burck.	seed (spotted)	3.6	(Ingle *et al*., 2003)
76.	*Mucuna Sloanei* Fawcett & Rendle	seed	3.34-9.0	(Ingle *et al.,* 2003)
77.	*Mucuna sp*	seed	1.96-4.96	(Ingle *et al*., 2003)
78.	*Mucuna urens*(Linn.) Medik.	seed	4.92-7.4	(Ingle *et al*., 2003)
79.	*Mucuna atterrima*	seed	4.50%	(Sushama *et al*., 2013)
80.	*Mucuna pruriens*	seed	3.54 % DW	(Sushama *et al*., 2013)
81.	*Mucuna pruriens* Var utilis (Velvet bean)	seed	6.36% W/W	(Sushama *et al*., 2013)
82.	*Mucuna pruriens*	seed	24g/DW	(Sushama *et al*., 2013)
83.	*Mucuna monospema*	seed	5.48% DW	(Sushama *et al.,* 2013)
84.	*Mucuna pruriens*	Seed	77.6826±3.1232 (µg/ml)	(Crapnell *et al*., 2023)
85.	*Mucuna bracteata* (µg/ml)	Seed	42.1153±2.8933	(Crapnell *et al*., 2023)
86.	*M.pruriens var.pruriens*	Seed	4.91-7.09	(Crapnell *et al*., 2023)
87.	*M.pruriens var.utilis*	Seed	1.22	(Crapnell *et al*., 2023)
88.	*Mucuna gigantea*	Seed	6.76	(Crapnell *et al*., 2023)
89.	*Mucuna nigricans*	Seed	6.16	(Crapnell *et al*., 2023)
90.	*Mucuna monosperma*	Seed	4.61	(Crapnell *et al*., 2023)

DOPA in these plants underscores the diversity of secondary metabolites within the plant kingdom and raises questions regarding their ecological roles, potential applications in traditional medicine, and implications for pharmacological research. Further exploration of these L-DOPA-rich plants could yield valuable insights into their biochemistry, ecological interactions, and possible therapeutic applications, broadening our understanding of the botanical world's chemical diversity (Bhattacharyya *et al*.,

Sr. No	Plant	Plant part	L-Dopa %	References
1	*Alysicarpus rugosus.*	Seed	0.65	(Ramya *et al.,* 2007)
2	*Bauhinia purpurea.*	Seed	2.2	(Ramya *et al.,* 2007)
3	*Bauhinia racemosa.*	Seed	0.73	(Ramya *et al.,* 2007)
4	*Canavalia ensiformis*	Seed	2.46	(Ramya *et al.,* 2007)
5	*Canavalia gladiata.*	Seed	2.13	(Ramya *et al.,* 2007)
6	*Cassia floribunda.*	Seed	1.1-1.9	(Ramya *et al.,* 2007)
7	*Cassia hirsute.*	Seed	2.37-2.82	(Ramya *et al*., 2007)
8	*Dalbergia retusa.*	Seed	2.2	(Ramya *et al.,* 2007)
9	*Glycine wightii.*	Seed	0.2	(Ramya *et al*., 2007)
10	*Parkinsonia aculeate.*	Seed	0.64	(Ramya *et al*., 2007)
11	*Phanera vahlii.*	Seed	2.35	(Ramya *et al*., 2007)
12	*Pileostigma malabarica.*	Seed	2.13	(Ramya *et al*., 2007)
13	*Prosopis chilensis.*	Seed	1.25	(Ramya *et al*., 2007)
14	*Vicia faba var minor*	Dry seed	0.07	(Ramya *et al*., 2007)
15	*Vicia faba var minor*	Green pods (whole unripe fruit)	0.6	(Ramya *et al*., 2007)
16	*Vicia faba var minor*	Green plant with pods	0.56	(Ramya *et al*., 2007)
17	*Vicia faba var minor*	Green flowering plant	0.40-0.46	(Ramya *et al*., 2007)
18	*Vicia faba var minor*	Green vegetative plant	0.24-0.57	(Ramya *et al*., 2007)
19	*Vicia narbonensis.*	Green pods (peel only)	0.5	(Ramya *et al*., 2007)
20	*Vigna aconitifolia.*	Seed	0.2	(Ramya *et al*., 2007)
21	*Vigna unguiculata.*	Seed	0.45	(Ramya *et al*., 2007)
22	*Vigna vexillata.*	Seed	0.52-0.58	(Ramya *et al*., 2007)
23	*Zendopa* (Commercialized Mucuna seed powder)	Seed powder	5.01 ± 0.08	(Rane *et al*., 2019)
24	*Stizolobium prurien* (L.) DC Var pruriens	seed	5.5	(Yang *et al*., 2001)
25	*S. pruriens (L.)* DC. var. utilis (Wall. ex Wight) Bak. ex Burck	seed	6.2	(Yang *et al.,* 2001)
26	*Alysicarpus rugosus* (Willd.) DC.	seed	0.65	(Ingle *et al*., 2003)
27	*Bauhinia purpurea* Linn	seed	2.2	(Ingle *et al*., 2003)
28	*Bauhinia racemosa* Lam	seed	0.73	(Ingle *et al*., 2003)
29	*Canavalia ensiformis* (Linn.) DC.	seed	2.46	(Ingle *et al*., 2003)
30	*Canavalia gladiata* (Jacq.)DC.	seed	2.13	(Ingle *et al*., 2003)
31	*Cassia floribunda* Cav.	Seed	1.1-1.9	(Ingle *et al*., 2003)
32	*Cassia hirsute* Linn.	seed	2.37-2.82	(Ingle *et al.,* 2003)
33	*Dalbergia retusa* Hemsl	seed	2.2	(Ingle *et al*., 2003)
34	*Glycine wightii.* (W. & A.) Verdc.	seed	0.2	(Ingle *et al*., 2003)
35	*parkinsonia aculeata* Linn.	Seed	0.64	(Ingle *et al*., 2003)
36	*phanera vahlii* Benth.	seed	2.35	(Ingle *et al*., 2003)
37	*Pileostigma malabrica* Benth.	seed	2.13	(Ingle *et al*., 2003)
38	*prospopis chilensis stuntz*	seed	1.25	(Ingle *et al*., 2003)
39	*Teramnus labialis* (Linn.) Spreng	seed	tr	(Ingle *et al*., 2003)
40	*vicia faba Linn.*	Green peel of pod	0.02-0.75	(Ingle *et al.,* 2003)
41	*Vicia faba var minor*	Dry seed	0.07	(Ingle *et al*., 2003)
42	*Vicia narbonensis Linn.*	Green plant with pods	0.50	(Ingle *et al.,* 2003)
43	*Vigna aconitifolia* (Jacq.) Marechal	seed	0.20	Sushama *et al*., 2013)
44	*Vigna unguiculata* (Linn.) Walp.	seed	0.45	Sushama *et al.,* 2013)
45	*Vigna vexillata* (Benth.)A. Rich.	seed	0.52-0.58	(Sushama *et al.,* 2013)

2022; Jagtap *et al*., 2010).

Discussion

More people worldwide are suffering from Parkinson's disease (PD) than any other neurological ailment, with higher rates of disability and mortality because of the disease's faster increasing prevalence **(**Prasathkumar *et al*., 2021; Sengupta *et al*., 2016).

Synthetic L-DOPA is usually given in combination with decarboxylase inhibitors as part of a therapeutic regimen. But it's crucial to remember that a significant fraction of patients receiving L-DOPA medication frequently have side effects such nausea, vomiting, and hypotensive episodes. Furthermore, prolonged synthetic L-DOPA treatment or increased bloodstream concentrations of L-DOPA have been linked to an increased risk of dyskinesia, a disorder marked by uncontrollably writhing motions affecting the trunk and limbs (Poewe *et al*., 2010). Research has shown that *Mucuna pruriens* (MP) can alleviate the undesirable consequences of dyskinesia *in vivo*, which is encouraging (Beckers *et al*., 2022; Safiri *et al*., 2023). Moreover, studies conducted on human participants have demonstrated that MP can lower the frequency of side effects, such as nausea, vertigo, sleeplessness, and psychological symptoms **(**Ovallath *et al*., 2017). These results point to the possible use of MP as a more effective and bearable substitute for L-DOPA therapy in the treatment of Parkinson's disease symptoms, especially in terms of reducing side effects.

Conclusion

Presently treatment of Parkinson's disease depends on L- DOPA based medicines, whereas continuous use of synthetic L-dopa can cause serious side effects such as dyskinesia, dizziness, headache and abnormal involuntary movement. Plants rich in L- DOPA content such as *Mucuna pruriens* Vica *beans* has significant amount L- DOPA content. Exploring natural plant-based L-DOPA for Parkinson's disease management in low-income countries holds promise as a cost-effective and potentially accessible approach to improving the quality of life of Parkinson's patients taking this drug. Further research is needed to better understand the long-term efficacy and safety of plant-based L-DOPA in the treatment of Parkinson's disease. However, in order to enlarge the scope of their scientific validation, clinical trials of these plants should be encouraged. To prove the efficacy of in clinical trials, Overall, plant-based L-DOPA holds promise as a complementary approach to conventional therapy, offering potential benefits for those living with Parkinson's disease.

References

Abbott, A. 2010. Levodopa: the story so far. *Nature.* 466 (7310): S6-S7.

Beckers, M., Bloem, B.R. and Verbeek, M.M. 2022. Mechanisms of peripheral levodopa resistance in Parkinson's disease. *npj Parkinson's Disease.* 8(1): 56.

Bloem, B.R., Okun, M.S. and Klein, C. 2021. Parkinson's disease. *Lancet*. 397(10291): 2284-2303.

Bhattacharyya, K.B. 2022. The story of levodopa: a long and arduous journey. *Annals of Indian Academy of Neurology*. 25(1): 124-130.

Crapnell, R.D. and Banks, C.E. 2023. Electroanalytical Overview: The Determination of Levodopa (L-DOPA). *ACS Measurement Science Au.* 3(2): 84-97.

Brauer, R., Wei, L., Ma, T., Athauda, D., Girges, C., Vijiaratnam, N., Auld, G., Whittlesea, C., Wong, I. and Foltynie, T. 2020. Diabetes medications and risk of Parkinson's disease: a cohort study of patients with diabetes. *Brain.* 143(10): 3067-3076.

DeMaagd, G. and Philip, A. 2015. Parkinson's disease and its management: part 1: disease entity, risk factors, pathophysiology, clinical presentation, and diagnosis. *Pharmacy and Therapeutics*. 40(8): 504-532.

Dorsey, E.R., Elbaz, A., Nichols, E., Abbasi, N., Abd-Allah, F., Abdelalim, A., Adsuar, J.C., Ansha, M.G., Brayne, C., Choi, J.Y.J. and Collado-Mateo, D. 2018. Global, regional, and national burden of Parkinson's disease, 1990–2016: a systematic analysis for the Global Burden of Disease Study 2016. *The Lancet Neurology*. 17(11): 939-953.

Dorszewska, J., Kowalska, M., Prendecki, M., Piekut, T., Kozlowska, J. and Kozubski, W. 2021. Oxidative stress factors in Parkinson's disease. *Neural Regeneration Research*. 16(7): 1383-1391.

Fothergill-Misbah, N., Maroo, H., Cham, M., Pezzoli, G., Walker, R. and Cilia, R. 2020. Could *Mucuna pruriens* be the answer to Parkinson's disease management in sub-Saharan Africa and other low-income countries worldwide? *Parkinsonism & Related Disorders*.73: 3-7.

Haddad, F., Sawalha, M., Khawaja, Y., Najjar, A. and Karaman, R., 2017. Dopamine and levodopa prodrugs for the treatment of Parkinson's disease. *Molecules*. 23(1):40.

Hornykiewicz, O. 2002. L-DOPA: From a biologically inactive amino acid to a successful therapeutic agent:

Historical review article. *Amino Acids.* 23(1-3): 65-70.
Inamdar, S.A., Surwase, S.N., Jadhav, S.B., Bapat, V.A. and Jadhav, J.P. 2013. Statistically optimized biotransformation protocol for continuous production of L-DOPA using Mucuna monosperma callus culture. *Springer Plus* 2(570):1-9.
Ingle, P.K. 2003. L-Dopa bearing plants. *Natural Product radiance.* 2(3):126-133.
Jagtap, S.D., Deokule, S.S., Mukharjee, S., Kuvalekar, A., Devkar, S. and Harsulkar, A.M. 2010. Assessment of nutritional value of some wild edible plants from Satpura hills of Maharashtra in India. *Journal of Herbal Medicine and Toxicology.* 4 (1) 77-82.
Mali, P., Kamble, P., Aware, C., Suryawanshi, S. and Jadhav, J. 2023. Extraction optimization of anti-Parkinson's medication L-DOPA and bioactive compounds from Mucuna atropurpurea (Roxb.) Wight & Arn. with biomedical potential: RSM based desirability function approach. *Journal of Applied Research on Medicinal and Aromatic Plants*. (34): 100451.
Min, K., Park, K., Park, D.H. and Yoo, Y.J. 2015. Overview on the biotechnological production of L-DOPA. *Applied Microbiology and Biotechnology*. 99(2): 575-584.
Murthy, S.N., Malgaonkar, M.M., Shirolkar, A.R., Pawar, S.D., Sangvikar, S. and Kulkarni, Y.R. 2015. A comparative assessment of pharmacologically active principles and antioxidant activity of commonly occurring *Mucuna* SPS in India. *International Journal of Ayurveda and Pharma Research*. 3(11): 8-13.
Ovallath, S. and Sulthana, B. 2017. Levodopa: History and therapeutic applications. *Annals of Indian Academy of Neurology*. 20(3): 185.
Parkinson Study Group, 2004. Levodopa and the progression of Parkinson's disease. *New England Journal of Medicine*. 351(24): 2498-2508.
Prasathkumar, M., Anisha, S., Dhrisya, C., Becky, R. and Sadhasivam, S. 2021. Therapeutic and pharmacological efficacy of selective Indian medicinal plants–a review. *Phytomedicine Plus*. 1(2): 100029.
Poewe, W., Antonini, A., Zijlmans, J.C., Burkhard, P.R. and Vingerhoets, F. 2010. Levodopa in the treatment of Parkinson's disease: an old drug still going strong. *Clinical Interventions in Aging*. (5): 229-238.
Ramya, K.B. and Thaakur, S. 2007. Herbs containing L-Dopa: an update. *Ancient Science of Kife*. 27(1): 50-55.
Rane, M., Suryawanshi, S., Patil, R., Aware, C., Jadhav, R., Gaikwad, S., Singh, P., Yadav, S., Bapat, V., Gurav, R. and Jadhav, J. 2019. Exploring the proximate composition, antioxidant, anti-Parkinson's and anti-inflammatory potential of two neglected & underutilized Mucuna species from India. *South African Journal of Botany*. 124: 304-310.
Raina, A.P. and Khatri, R. 2011. Quantitative determination of L-DOPA in seeds of Mucuna pruriens germplasm by high performance thin layer chromatography. *Indian Journal of Pharmaceutical Sciences*. 73(4): 459.
Safiri, S., Noori, M., Nejadghaderi, S.A., Mousavi, S.E., Sullman, M.J., Araj-Khodaei, M., Singh, K., Kolahi, A.A. and Gharagozli, K. 2023. The burden of Parkinson's disease in the Middle East and North Africa region, 1990–2019: Results from the global burden of disease study 2019. *BMC Public Health*. 23(1): 107.
Sengupta, T., Vinayagam, J., Singh, R., Jaisankar, P. and Mohanakumar, K.P. 2016. Plant-derived natural products for Parkinson's disease therapy. The benefits of natural products for neurodegenerative diseases. *Advances in Neurobiology.* 12: 415-496.
Bapat, S.V., Gurav, R. and Jadhav, J. 2019. Exploring the proximate composition, antioxidant, anti-Parkinson's and anti-inflammatory potential of two neglected and underutilized Mucuna species from India. *South African Journal of Botany*. 124: 304-310.
Sushama, A.P., Onkar A, A., Shripad N, S. and Jyoti P.J. 2013. Biological sources of L-DOPA: An alternative approach. *Advances in Parkinson's Disease*. 2(3): 81-87.
Vilairat, C., Kobtrakul, K. and Vimolmangkang, S. 2023. Enhanced Physico-chemical Stability of the L-DOPA Extract of Mucuna pruriens Seeds by Adding Phyllanthus emblica. *Molecules*. 28(4): 1573.
Yang, X., Zhang, X. and Zhou, R. 2001. Determination of L-Dopa content and other significant nitrogenous compounds in the seeds of seven Mucuna and Stizolobium species in China. *Pharmaceutical Biology*. 39(4): 312-316.
Zheng, Z., Zhu, Z., Zhou, C., Cao, L. and Zhao, G. 2023. Burden of Parkinson Disease in China, 1990–2019: Findings from the 2019 Global Burden of Disease Study. *Neuroepidemiology*. 57(1): 51-64.